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Rev B

Integrated AMSU-A
Earth Observing System (EOS)
Advanced Microwave Sounding Unit-A (AMSU-A)
Engineering Telemetry Description

Contract No: NAS 5-32314
CDRL: 305

Submitted to:

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Submitted by:

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SECTION 1

1.1 SCOPE

This document "Engineering Telemetry Description" contains description of the telemetry provided by EOS/AMSU-A instrument, which shall be monitored to evaluate operation and status of the instrument during instrument spacecraft integration, acceptance/qualification testing and in-orbit operation. The "Engineering Telemetry Description" is the submittal in response to Contract NAS5-32314, CDRL 305.

SECTION 2

EOS/AMSU-A TELEMETRY LIST AND DESCRIPTION

2.0 EOS/AMSU-A TELEMETRY.

EOS/AMSU-A provides 1) Passive Analog and 2) Engineering Telemetry Data.

2.1 PASSIVE ANALOG TELEMETRY

The passive analog telemetry are provided to sample critical temperatures within the instrument. These are tabulated in Table 1 and Table 2 for AMSU-A1 and AMSU-A2 respectively. Mission critical thermisters are the RF shelf temperatures and redundancy is provided for these critical thermisters. EOS/AMSU-A1 and AMSU-A2 passive analog telemetry lists and limits are provided in Table 1 and Table 2 respectively. Also, passive analog telemetry will provide passive indicators for Bus A and Bus B. Temperature vs resistance curves for each temperature sensor will be provided in calibration log book.

2.2 ENGINEERING TELEMETRY DATA

Engineering Telemetry data consists of analog telemetry and digital telemetry. The Engineering telemetry data list and limits are provided in Table 3 and Table 4 for AMSU-A1 and AMSU-A2 respectively.

2.2.1 ANALOG TELEMETRY DATA

Analog telemetry data transmitted from the EOS/AMSU-A instrument consist of secondary voltages, bus currents, and instrument temperatures. These parameters are multiplexed, digitized, and made available to the spacecraft via the MIL-STD-1553 bus as Engineering data.

2.2.1.1 Instrument temperature sensors:

For instrument temperature sensors (refer to data word 13 through 57, Table 3 and data word 12 through 30, Table 4) parameter is defined by a set of functions. The coefficients will be provided in calibration log book for each PRT temperature sensor.

Platinum resistance temperature sensors (PRTs) are used throughout the instrument to monitor key temperatures. These sensors each have unique coefficients based on the manufacturer's data. PRT circuit calibration is performed during the instrument integration level test.

TABLE - 1 PASSIVE ANALOG TELEMETRY DATA LIMITS FOR AMSU-A1

J2 PIN NUMBER		DESCRIPTION	Red Limit (Low)	Yellow Limit (Low)	Yellow Limit (High)	Red Limit (High)
HI	LOW		Deg. C	Deg. C	Deg. C	Deg. C
1	2	A1-1 Scan Motor Temperature	-30	-20	58	66
7	8	A1-2 Scan Motor Temperature	-30	-20	58	66
3	4	A1-1 RF Shelf Temperature #1	-30	-20	58	66
9	10	A1-2 RF Shelf Temperature #1	-30	-20	58	66
5	6	A1-1 Warm Load Temperature	-30	-20	58	66
11	12	A1-2 Warm Load Temperature	-30	-20	58	66
22	23	A1-1 RF Shelf Temperature #2	-30	-20	58	66
28	29	A1-2 RF Shelf Temperature #2	-30	-20	58	66
19	18	Quiet Bus Indicator*	N/A	N/A	N/A	N/A
37	36	Noisy Bus Indicator**	N/A	N/A	N/A	N/A

*Quite Bus Indicator
Bus A 1KΩ ±10%
Bus B 2KΩ ±10%
**Noisy Bus Indicator
Bus A 1KΩ ±10%
Bus B 2KΩ ±10%

TABLE - 2 PASSIVE ANALOG TELEMETRY DATA LIMITS FOR AMSU-A2

J2 PIN NUMBER		DESCRIPTION	Red Limit (Low) Deg. C	Yellow Limit (Low) Deg. C	Yellow Limit (High) Deg. C	Red Limit (High) Deg. C
HI	LOW					
1	2	Scan Motor Temperature	-30	-20	58	66
3	4	RF Shelf Temperature #1	-30	-20	58	66
5	6	Warm Load Temperature	-30	-20	58	66
22	23	RF Shelf Temperature #2	-30	-20	58	66
19	18	Quiet Bus Indicator*	N/A	N/A	N/A	N/A
37	36	Noisy Bus Indicator**	N/A	N/A	N/A	N/A

*Quite Bus Indicator
Bus A 1KΩ ±10%
Bus B 2KΩ ±10%
**Noisy Bus Indicator
Bus A 1KΩ ±10%
Bus B 2KΩ ±10%

TABLE - 3 (Page 1 of 2)
EOS/AMSU-A1 ENGINEERING TELEMETRY DATA AND LIMITS

DATA WORD	*FUNCTION MONITORED*	U N I T	INDICATOR LIMIT (LOW)	LOW* LIMIT	NOMINAL @	HIGH* LIMIT	INDICATOR LIMIT (HIGH)
1	Primary Header - Packet ID				N/A		
2	Primary Header - Packet Sequence Control				N/A		
3	Primary Header - Packet Length				N/A		
4	Secondary Header				N/A		
5	Secondary Header				N/A		
6	Secondary Header				N/A		
7	Secondary Header				N/A		
8	Secondary Header (Plus one dummy zero byte)				N/A		
9	Unit Serial Number				N/A		
10	Instrument Mode and Relay Status		N/A	N/A	FIGURE 1	N/A	N/A
11	Reflector Position (A1-1 Antenna)	CO	N/A	m-8	m	m+16	N/A
12	Reflector Position (A1-2 Antenna)	CO	N/A	n-8	n	n+16	N/A
13	1 Scan Motor A1-1 Temperature	°C	-10	N/A		N/A	+48
14	2 Scan Motor A1-2 Temperature	°C	-10	N/A		N/A	+48
15	3 Feedhorn A1-1	°C	-10	N/A		N/A	+48
16	4 Feedhorn A1-2	°C	-10	N/A		N/A	+48
17	5 RF Mux - A1-1 Temperature	°C	-10	N/A		N/A	+48
18	6 RF Mux - A1-2 Temperature	°C	-10	N/A		N/A	+48
19	7 Local Oscillator - Channel 3 Temperature	°C	-10	-1		+44	+48
20	8 Local Oscillator - Channel 4 Temperature	°C	-10	-1		+44	+48
21	9 Local Oscillator - Channel 5 Temperature	°C	-10	-1		+44	+48
22	10 Local Oscillator - Channel 6 Temperature	°C	-10	-1		+44	+48
23	11 Local Oscillator - Channel 7 Temperature	°C	-10	-1		+44	+48
24	12 Local Oscillator - Channel 8 Temperature	°C	-10	-1		+44	+48
25	13 Local Oscillator - Channel 15 Temperature	°C	-10	-1		+44	+48
26	14 Phase Locked Oscillator No. 2 Temperature	°C	-10	+1		+44	+48
27	15 Phase Locked Oscillator No. 1 Temperature	°C	-10	+1		+44	+48
28	16 S.P. (1553 Interface) Temperature	°C	-10	N/A		N/A	+48
29	17 Mixer/IF Amplifier - Channel 3 Temperature	°C	-10	N/A		N/A	+48
30	18 Mixer/IF Amplifier - Channel 4 Temperature	°C	-10	N/A		N/A	+48
31	19 Mixer/IF Amplifier - Channel 5 Temperature	°C	-10	N/A		N/A	+48
32	20 Mixer/IF Amplifier - Channel 6 Temperature	°C	-10	N/A		N/A	+48
33	21 Mixer/IF Amplifier - Channel 7 Temperature	°C	-10	N/A		N/A	+48
34	22 Mixer/IF Amplifier - Channel 8 Temperature	°C	-10	N/A		N/A	+48
35	23 Mixer/IF Amplifier - Channel 9/14 Temp	°C	-10	N/A		N/A	+48
36	24 Mixer/IF Amplifier - Channel 15 Temperature	°C	-10	N/A		N/A	+48
37	25 IF Amp - Channel 11/14 Temperature	°C	-10	N/A		N/A	+48
38	26 IF Amp - Channel 9 Temperature	°C	-10	N/A		N/A	+48
39	27 IF Amp - Channel 10 Temperature	°C	-10	N/A		N/A	+48
40	28 IF Amp - Channel 11 Temperature	°C	-10	N/A		N/A	+48
41	29 DC/DC Converter Temperature	°C	-10	N/A		N/A	+48

* INSTRUMENT WITHIN SPECIFICATION

@ Nominal values for reflector position (m & n) will be provided in Calibration Log Book. Nominal values for temperatures will be provided after completion of thermal balance test. All other nominal values will be provided after first Comprehensive Performance Test.

TABLE - 3 (Page 2 of 2)
EOS/AMSU-A1 ENGINEERING TELEMETRY DATA AND LIMITS

DATA WORD	*FUNCTION MONITORED*	UNIT	INDICATOR LIMIT (LOW)	LOW* LIMIT	NOMINAL @	HIGH* LIMIT	INDICATOR LIMIT (HIGH)
42	30 IF Amp - Channel 13 Temperature	°C	-10	N/A		N/A	+48
43	31 IF Amp - Channel 14 Temperature	°C	-10	N/A		N/A	+48
44	32 IF Amp - Channel 12 Temperature	°C	-10	N/A		N/A	+48
45	33 RF Shelf - A1-1 Temperature	°C	-10	-2		+38	+48
46	34 RF Shelf - A1-2 Temperature	°C	-10	-2		+38	+48
47	35 Detector/Preamplifier Temperature	°C	-10	N/A	N/A	N/A	+48
48	36 A1-1 Warm Load 1 Temperature	°C	-15	N/A	N/A	N/A	+40
49	37 A1-1 Warm Load 2 Temperature	°C	-15	N/A	N/A	N/A	+40
50	38 A1-1 Warm Load 3 Temperature	°C	-15	N/A	N/A	N/A	+40
51	39 A1-1 Warm Load 4 Temperature	°C	-15	N/A	N/A	N/A	+40
52	40 A1-1 Warm Load Center Temperature	°C	-15	N/A	N/A	N/A	+40
53	41 A1-2 Warm Load 1 Temperature	°C	-15	N/A	N/A	N/A	+40
54	42 A1-2 Warm Load 2 Temperature	°C	-15	N/A	N/A	N/A	+40
55	43 A1-2 Warm Load 3 Temperature	°C	-15	N/A	N/A	N/A	+40
56	44 A1-2 Warm Load 4 Temperature	°C	-15	N/A	N/A	N/A	+40
57	45 A1-2 Warm Load Center Temperature	°C	-15	N/A	N/A	N/A	+40
58	PRT Reference Voltage	CO	N/A	N/A		N/A	N/A
59	Signal Processor +5 Volts	V	N/A	+4	+5	+6	N/A
60	Signal Processor +15 Volts	V	N/A	+14	+15	+16	N/A
61	Signal Processor -15 Volts	V	N/A	-16	-15	-14	N/A
62	Scan Drive +5 Volts	V	N/A	+4	+5	+6	N/A
63	Scan Drive +15 Volts	V	N/A	+13	+15	+17	N/A
64	Scan Drive -15 Volts	V	N/A	-17	-15	-13	N/A
65	PLO +15 Volts	V	N/A	+14	+15	+16	N/A
66	PLO -15 Volts	V	N/A	-16	-15	-14	N/A
67	Receiver +8 Volts	V	N/A	+7	+8	+9	N/A
68	Mixer/IF Amplifier - A1-1 +10 Volts	V	N/A	+9	+10	+11	N/A
69	Mixer/IF Amplifier - A1-2 +10 Volts	V	N/A	+9	+10	+11	N/A
70	Local Oscillator - Channel 6 +10 Volts	V	N/A	+9	+10	+11	N/A
71	Local Oscillator - Channel 7 +10 Volts	V	N/A	+9	+10	+11	N/A
72	Local Oscillator - Channel 15 +10 Volts	V	N/A	+9	+10	+11	N/A
73	Local Oscillator - Channel 3+10 Volts	V	N/A	+9	+10	+11	N/A
74	Local Oscillator - Channel 4 +10 Volts	V	N/A	+9	+10	+11	N/A
75	Local Oscillator - Channel 5 +10 Volts	V	N/A	+9	+10	+11	N/A
76	Local Oscillator - Channel 8 +10 Volts	V	N/A	+9	+10	+11	N/A
77	Local Oscillator - Channel 15 +15 Volts	V	N/A	+9	+10	+11	N/A
78	A1 Quiet Bus Current	A	N/A	N/A		3.21	N/A
79	A1-1 Noisy Power Bus Current	A	N/A	N/A		0.107	N/A
80	A1-2 Noisy Power Bus Current	A	N/A	N/A		0.107	N/A

V = Vdc
A = Ampere
CO = Counts

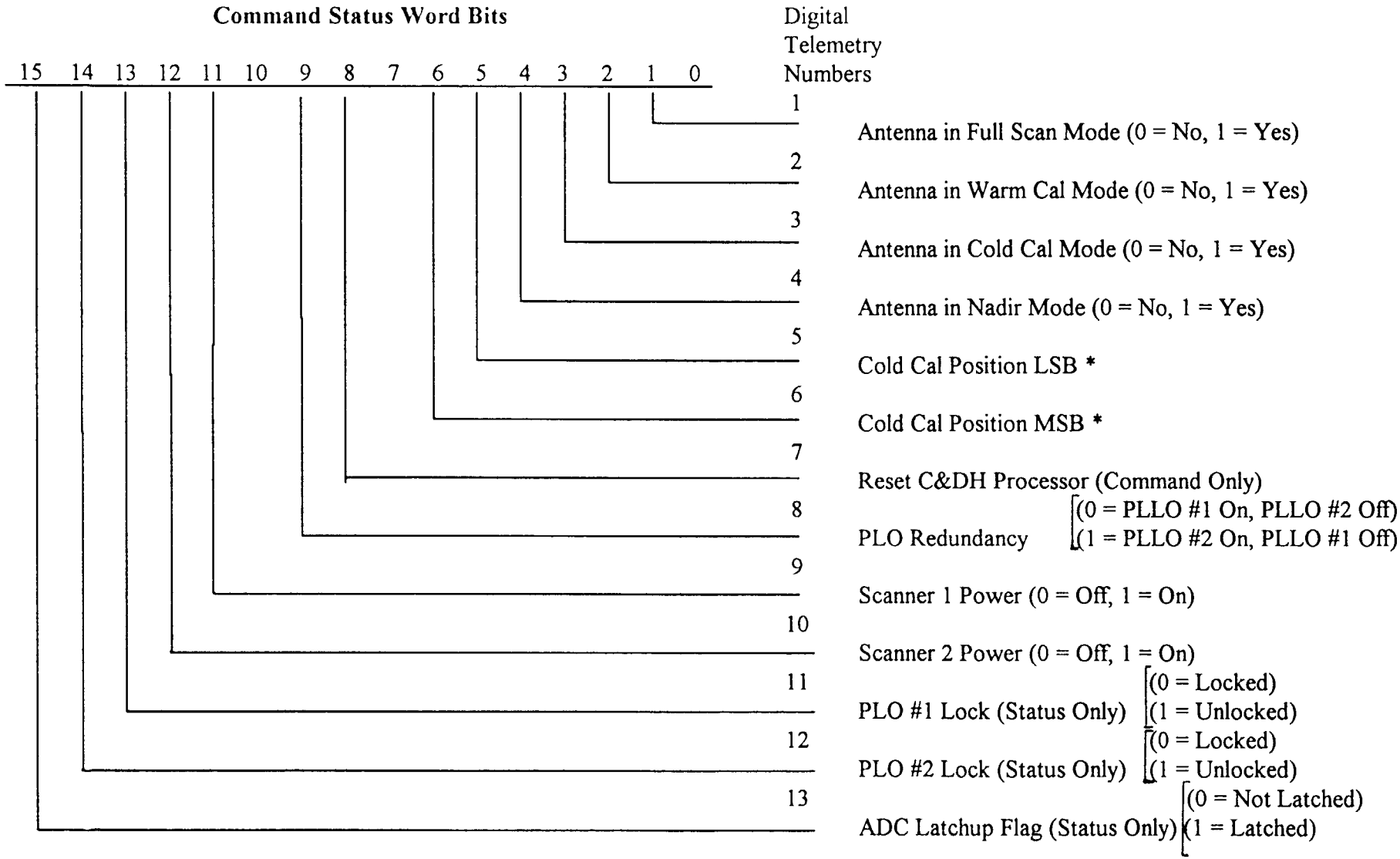

Figure 1. EOS / AMSU - A1 Command / Status

* Cold Cal Pos.	MSB	LSB
1	0	0
2	0	1
3	1	0
4	1	1

TABLE - 4
EOS/AMSU-A2 ENGINEERING TELEMETRY DATA AND LIMITS

DATA WORD	*FUNCTION MONITORED*	UNIT	INDICATOR LIMIT (LOW)	LOW* LIMIT	NOMINAL @	HIGH* LIMIT	INDICATOR LIMIT (HIGH)
1	Primary Header - Packet ID				N/A		
2	Primary Header - Packet Sequence Control				N/A		
3	Primary Header - Packet Length				N/A		
4	Secondary Header				N/A		
5	Secondary Header				N/A		
6	Secondary Header				N/A		
7	Secondary Header				N/A		
8	Secondary Header (Plus one dummy zero byte)				N/A		
9	Unit Serial Number				N/A		
10	Instrument Mode and Relay Status		N/A	N/A	FIGURE 2	N/A	N/A
11	Reflector Position	CO	N/A	m-8	m	m+16	N/A
12	1 Scan Motor A1-1 Temperature	°C	-10	N/A		N/A	+48
13	2 Feedhorn Temperature	°C	-10	N/A		N/A	+48
14	3 RF Diplexer Temperature	°C	-10	N/A		N/A	+48
15	4 Mixer/IF Amplifier - Channel 1 Temperature	°C	-10	N/A		N/A	+48
16	5 Mixer/IF Amplifier - Channel 2 Temperature	°C	-10	N/A		N/A	+48
17	6 Local Oscillator - Channel 1 Temperature	°C	-10	-5			+48
18	7 Local Oscillator - Channel 2 Temperature	°C	-10	-5			+48
19	8 S.P. (1553 Interface) Temperature	°C	-10	N/A			+48
20	9 Subreflector Temperature	°C	-10	N/A			+48
21	10 DC/DC Converter Temperature	°C	-10	N/A			+48
22	11 RF Shelf - Temperature	°C	-10	-7			+48
23	12 Detector/Preamplifier Temperature	°C	-10	N/A		N/A	+48
24	13 Warm Load Center Temperature	°C	-15	N/A	N/A	N/A	+40
25	14 Warm Load 2 Temperature	°C	-15	N/A	N/A	N/A	+40
26	15 Warm Load 3 Temperature	°C	-15	N/A	N/A	N/A	+40
27	16 Warm Load 4 Temperature	°C	-15	N/A	N/A	N/A	+40
28	17 Warm Load 5 Temperature	°C	-15	N/A	N/A	N/A	+40
29	18 Warm Load 6 Temperature	°C	-15	N/A	N/A	N/A	+40
30	19 Warm Load 1 Temperature	°C	-15	N/A	N/A	N/A	+40
31	PRT Reference Voltage	CO	N/A	N/A		N/A	N/A
32	Signal Processor +5 Volts	V	N/A	+4	+5	+6	N/A
33	Signal Processor +15 Volts	V	N/A	+14	+15	+16	N/A
34	Signal Processor -15 Volts	V	N/A	-16	-15	-14	N/A
35	Scan Drive +5 Volts	V	N/A	+4	+5	+6	N/A
36	Scan Drive +15 Volts	V	N/A	+13	+15	+17	N/A
37	Scan Drive -15 Volts	V	N/A	-17	-15	-13	N/A
38	Receiver +8 Volts	V	N/A	+7	+8	+9	N/A
39	Mixer/IF Amplifier +10 Volts	V	N/A	+9	+10	+11	N/A
40	Local Oscillator - Channel 1 +10 Volts	V	N/A	+9	+10	+11	N/A
41	Local Oscillator - Channel 2 +10 Volts	V	N/A	+9	+10	+11	N/A
42	A2 Quiet Bus Current	A	N/A	N/A		1.25	N/A
43	A2 Noisy Power Bus Current	A	N/A	N/A		0.214	N/A

* INSTRUMENT WITHIN SPECIFICATION

@ Nominal values for reflector position (m & n) will be provided in Calibration Log Book. Nominal values for temperatures will be provided after completion of thermal balance test. All other nominal values will be provided after first Comprehensive Performance Test.

V = Vdc

A = Ampere

CO = Counts

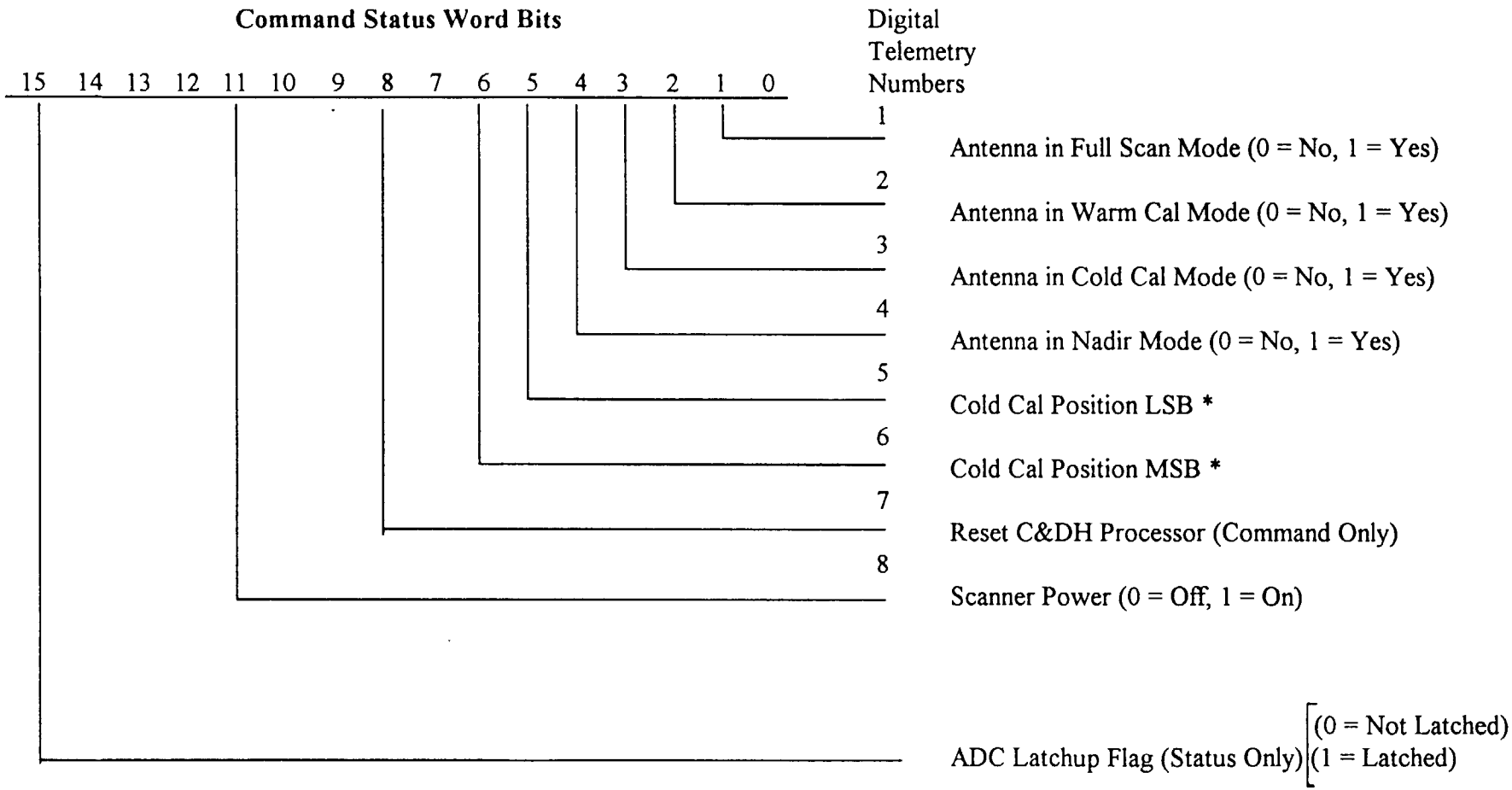

Figure 2. EOS / AMSU - A2 Command / Status

* COLD CAL. POS.	MSB	LSB
1	0	0
2	0	1
3	1	0
4	1	1

The signal from each PRT is digitized via an A to D converter aboard the AMSU A instrument. During operation, the instrument provides a count from 0 to 32,768 representing the temperature of a given PRT. Calibration of the PRT circuits will be performed during system integration and test which yields a discrete count vs. ohms relationship. This count to resistance relationship is made continuous via a third order polynomial fit to the data every 25 ohms, from 3725 ohms to 4600 ohms, for the in-flight warm calibration load (0.1K accuracy PRTs). The other instrument PRTs (0.5K accuracy) are represented by a polynomial fit to the data every 40 ohms from 1980 to 2380 ohms. The resulting equation gives the resistance as a function of counts (c) for a given i^{th} PRT:

$$R_i(c) = A_i c^3 + B_i c^2 + C_i c + D_i \qquad \text{Equation 1}$$

where: c = # of counts measured for i^{th} PRT
A_i, B_i C_i & D_i will be supplied in Cal Log Book

The Callendar-Van Dusen algorithm is then implemented once the resistance $R_i(c)$ is known to determine the physical temperature of each i^{th} PRT. This equation is given by:

$$\mathbf{R_i} = \mathbf{R_{oi}}\left[1+\alpha_i\left(t-\delta_i\left(\frac{t}{100}-1\right)\left(\frac{t}{100}\right)-\beta\left(\frac{t}{100}-1\right)\left(\frac{t}{100}\right)^3\right)\right] \qquad \text{Equation 3}$$

Where:

t = physical temperature of PRT
Ri = resistance (ohms) of i^{th} PRT (from equation 1)
Roi = resistance at ice point of i^{th} PRT (supplied by PRT vendor)
αi, δI = constants measured for i^{th} PRT (supplied by PRT vendor)
$\beta = 0$ (The in-flight PRT operating range is -10 C to +48 C for Instrument PRT and -15 C to 40 C for warm load PRT)

2.2.1.2 Voltage and current data:

For voltage and current data (refer to data word 54 through 80, Table 3 and data word 32 through 43, Table 4), the measured parameter is defined by the linear functions:

Measured parameter, $X = mN + b$

where N is the data count reported for the parameter.

The m and b will be derived from the comprehensive and calibration performance testing and will be provided in calibration log book.

2.2.1.3 Reflector Position:

Reflector positions (refer to data word 11 & 12, Table 3 AMSU-A1 and data word 11, Table 4 AMSU-A2) are derived from antenna range testing. Antenna position for warm cal, cold cal, Nadir and full scan are determined at antenna range. The required antenna position data (Position vs Count) will be provided in the calibration log book.

2.2.2 DIGITAL TELEMETRY DATA

Digital telemetry data (refer to data word 10, 11 & 12, Table 3 and 10 & 11, Table 4) transmitted from the EOS/AMSU-A instrument consists of command status, instrument modes, antenna power relay states, PLO lock status, ADC latchup flag. The digital telemetry data are depicted in Figure 1 and Figure 2. Digital telemetry number 1 through 6 for both A1 and A2 is a response to the appropriate commands. Digital telemetry number 9 and 10 in Figure 1 for AMSU-A1 and number 8 in Figure 2 for AMSU-A2 provides the status of scanner power off or on. Number 8 telemetry in Figure 1 for AMSU-A1 indicates PLO #1 or PLO #2 is on or off. Telemetry number 11 and 12 provides PLO lock status. Digital telemetry 13 in Figure 1 and number 9 in Figure 2 provides ADC latchup flag. PLO lock detect and ADC latchup flag requires action. If PLO is not locked then redundant PLO needs to be selected. If ADC latchup flag triggers then discard the data for that specific scan. Reset C&DH Processor (#7) is for command only and should be ignored.

2.2.3 DATA WORD FORMAT

Data word format is provided in Table 5

TABLE 5

	DATA WORD		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
For A1 REFER To TABLE #3	10	Command Status	D	D	D	D	D	X	D	D	X	D	D	D	D	D	D	X
	11,12	Reflector Position	D	D	D	D	D	D	D	D	D	D	D	D	D	D	X	O
	13 through 57	Temp. Data	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	O
	59 through 80	Voltage & Current	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	O
For A2 REFER To TABLE #4	10	Command Status	D	X	X	X	D	X	X	D	X	D	D	D	D	D	D	X
	11	Reflector Position	D	D	D	D	D	D	D	D	D	D	D	D	D	D	X	O
	12 through 30	Temp. Data	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	O
	32 through 43	Voltage & Current	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	O

D = DATA
X = IGNORE
O = ZERO

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15. Supplementary Notes

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16. ABSTRACT (*Maximum 200 words*)

This is the Engineering Telemetry Description for the METSAT Advanced Microwave Sounding Unit-A (AMSU-A).

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REPORT DOCUMENTATION PAGE

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1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
METSAT Advanced Microwave Sounding Unit -A (AMSU-A), Engineering Telemetry Description

5. FUNDING NUMBERS
NAS 5-32314

6. AUTHOR(S)
P. Patel

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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Greenbelt, Maryland 20771

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
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11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE
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13. ABSTRACT (*Maximum 200 words*)

This is the Engineering Telemetry Description for the Integrated Advanced Microwave Sounding Unit-A (AMSU-A)

14. SUBJECT TERMS
EOS
Microwave System

15. NUMBER OF PAGES
14

16. PRICE CODE
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17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

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